only. Therefore the sons of the daughters, or sisters, of successful naval fighters are more apt to be successful naval men than are the sons or the sons' sons of fighters, unless (as often happens) these fighting fathers marry daughters or sisters of naval men.

Hyperkinesis in either parent gives a favorable prognosis for naval success in the son: but some of the very best naval fighters have been hypokinetics and, under modern conditions of naval warfare, this type is less handicapped than formerly.

Four typical family pedigrees are annexed.

List of the 14 naval officers utilized in this study:—

Bainbridge (U. S.), Barney (U. S.), Cushing (U. S.), Cochrane (Eng.), Paul-Jones (U. S.), Lawrence (U. S.), MacDonough (U. S.), Keppel (Eng.), Maffitt (U. S.), Morris (U. S.), Perkins (U. S.), Porter (U. S.), Battnall (U. S.), Wolsely (Eng.).

THE TRIPLET SERIES OF RADIUM

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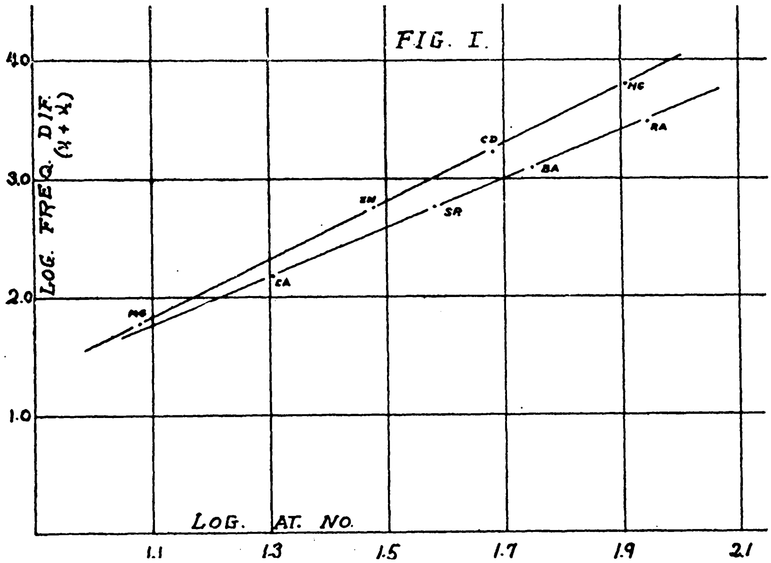
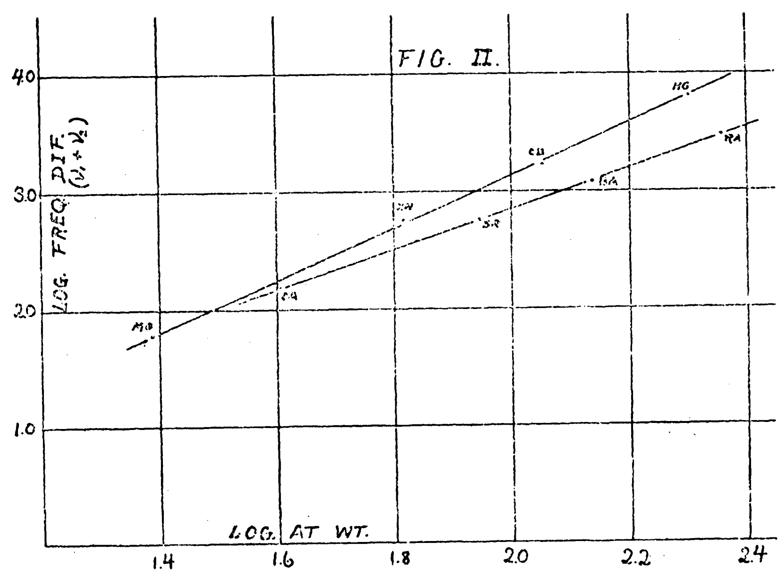
Many attempts have been made to establish a relationship between the spectra of elements and their atomic weights. Referring to the doublets which occur in the first and second subordinate series, Runge and Precht[1] stated the following law. "In each group of chemically related elements the atomic weight varies as some power of the distance apart of a pair." They applied this law to the group of alkaline earths, and when they plotted the logarithm of the frequency difference of the pair series in each element against the logarithm of the atomic weight they obtained a straight line which gave by extrapolation an atomic weight of 257.8 for radium. As this was too large a value Ives and Stuhlmann[2] replotted the results of Runge and Precht using the atomic number in place of the atomic weight. Although their results were in general more consistent the atomic number found for radium was 96 instead of 88.

Now the elements of the second group of the periodic table are characterized by the presence of both doublet and triplet series of the principal, first, and second subordinate types. On plotting the logarithms of the atomic numbers against the logarithms of the frequency differences between the extreme members of the triplets we found that alternate elements fall on straight lines as in figure 1. Therefore the triplets of radium should fall on a line with calcium, strontium, and barium. The



line through these three elements showed that the frequency difference of radium triplets should be approximately 3060. An examination of the known radium lines, measured by Runge and Precht,[3] showd a number of triplets with the average frequency differences, $\nu_1 = 2016.64$; $\nu_2 = 1036.15$; and $\nu_1 + \nu_2 = 3052.79$. Two triplets showed well marked satellites and seemed to belong definitely to the first subordinate series. Although a study of the magnetic resolution of these lines will be neces-



sary to establish the triplets, there seems little reason to doubt that the frequency difference 3053 is characteristic of the radium spectrum.

In figure 2 the logarithms of the frequency differences are plotted against the logarithms of the atomic weights. The general result is the same, but less accurate than in figure 1. The points plotted for radium in figures 1 and 2 are the points found with the actual values for the atomic number and the atomic weight. They fall almost exactly on the lines through calcium, strontium, and barium, in the one case above the line, in the other case below. Extrapolating from the curve we find values of 87 for the atomic number and of 231.7 for the atomic weight, which are remarkably close to the true values, 88 and 226.

The triplets as identified so far are given in table 1. H indicates principal series; I N first subordinate; and II N second subordinate.

TABLE 1

	λ IN A. U.	INT.	$\frac{10^8}{\lambda}$	FREQUENCY DIFFERENCE		λ IN A. U.	INT.	$\frac{10^8}{\lambda}$	FREQUENCY DIFFERENCE
H III 1	6200.6	10	16127.47		I N II 3	5081.2	6	19680.39	2015.07
				1043.15				129.04	
H II 1	5823.9	5	17170.62		I N II 3	5048.1	1	19809.43	2017.74
				2038.13				93.05	
H I 1	5205.96	6	19208.75		I N II 3	5024.5	1	19902.48	2017.77
					I N III 3	4826.12	20	20720.58	1040.19
II N I 3	5958.4	10	16783.03					99.31	
				2015.06	I N III 3	(4803.1)	2	20819.89	1010.46
II N II 3	6319.69	6	18798.09						
				1037.2	I N I 4	4882.3	2	20482.15	
II N III 3	5041.52	6	19835.29					95.35	
					I N I 4	4859.7	1	20577.40	
II N I 4	4997.4	1	20010.41					94.05	
II N II 4				3060.20	I N I 4	4837.59	2	20671.45	
II N III 4	4334.5	5	23070.71						
					I N II 4	4444.4	2	22500.22	2018.07
I N I 3	5660.81	10	17665.32					93.54	
			126.37		I N II 4	4426.0	4	22593.76	2016.36
I N I 3	5620.6	3	17791.69						
			92.92		I N III 4	4245.4	2	23554.91	1054.69
I N 1 3	5591.4	1	17884.61						

In addition to the series triplets in table 1 there are three pairs with a frequency difference of 1035.34 and one of 2017.57 as shown in table 2. There is one weak triplet at λλ 6487.4, 5729.2, and 5409.16 with $\nu_1 + \nu_2 = 3071.16$, which does not fit into any series. A stronger pair at λλ 4903.2 and 4265.1 with a frequency difference of 3051.27 may possibly be a part of the I N 4 group.

TABLE 2

	λ IN A. U.	INT.	$\frac{10^8}{\lambda}$	FREQUENCY DIFFERENCE		λ IN A. U.	INT.	$\frac{10^8}{\lambda}$	FREQUENCY DIFFERENCE
	6167.4	8	16214.29			4366.5	4	22901.64	
				1038.41					1033.25
	5796.2	5	17252.70			4178.0	6	23934.89	
	5811.7	3	17206.67			5907.4	2	16927.92	
				1034.35					2017.57
	5482.15	6	18241.02			5278.3	1	18945.49	

A preliminary attempt at a Rydberg formula gives the following results for the first line of the three classes of triplets:

$$\text{Principal series,} \qquad n = 44349.0 - \frac{109675}{(m + 1.0855)^2}$$

$$\text{First subordinate series,} \qquad n = 25236.8 - \frac{109675}{(m + .8062)^2}$$

$$\text{Second subordinate series,} \qquad n = 25153.0 - \frac{109675}{(m + .6196)^2}$$

It is very probable that further investigation will modify these formulae, but the existence of the triplets seems well established, and the fact that alternate elements in the chemical table show a spectroscopic relation is suggestive for further work along this line.

[1] Runge, C., and Precht, J., *Phil. Mag.*, *London*, **5**, 1903, (476).
[2] Ives, H. E., and Stuhlmann, O., *Physic. Rev.*, *Ithaca*, *N. Y.*, (Ser. 2), **5**, 1915, (368).
[3] Kayser, H., *Handbuch der Spectroscopie*, vol. 6, p. 325.

THE MEASUREMENT OF SMALL ANGLES BY DISPLACEMENT INTERFEROMETRY

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Parallel rays retracing their path.—The following method was devised with a view to the micrometric measurement of angles. It is to be used below in connection with an electrometer for reading microvolts. An interference method of a different kind for measuring small angles was developed some time since and used at length in connection with the deviation of the horizontal pendulum.[2] Again the electrometer was treated in different ways[3] by the aid of the displacement interferometer. The present method, however, will differ from all of these. In figure 1, L is a horizontal beam of white light from a collimator. After passing